FLUID LEVEL SENSING UTILIZING A MUTUAL CAPACITANCE TOUCHPAD DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present invention incorporates by reference all of the subject matter of issued U.S. Pat. No. 6,680,731 B2.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] This invention relates generally to fluid level sensing devices. More specifically, the invention relates to the application of capacitive sensor-based touchpad technology in a fluid level sensor, wherein the touchpad is disposed on an exterior container wall, is able to conform to contours of the container wall, and provide precise fluid level sensing along its length. The invention also relates to the sensing of solids and gases using the same touchpad technology.

[0004] 2. Description of Related Art

[0005] The need for accurate fluid level sensing is well known to those skilled in the art. Accurate determination of fluid levels has both industrial and environmental applications. Industrial applications include the measuring of petrochemicals at industrial and commercial sites. It is often the case that the containers for these materials are difficult to reach. Environmental applications include the monitoring of water levels in reservoirs, rivers, and even streams. Because of the diverse types of fluids (including gases and solids capable of flowing) that need to be monitored, the locations of containers, and the environments in which the fluids must be measured, the state of the art of the sensors used is quite varied.

[0006] Along with the variety of sensors, another common factor is the cost. Many such sensors used at industrial sites can cost nearly $100,000 per device.

[0007] The different types of technology used in the sensors include capacitance-sensitive devices that require multiple sensing devices, probes that utilize RF circuitry, complex arrays of sensors, moving probes, and sensors that can only be external to a container. There has been extensive development of fluid level sensors that can be used in various environments and with different fluids. Generally the sensors suffer from various drawbacks, not the least of which is that they can be complicated, expensive, unreliable, and applicable to only one type of fluid, or applicable in either a wet or a dry condition, but not both. There are also various other drawbacks specific to each type of technology being used.

[0008] Accordingly, it would be an advantage over the state of the art of current fluid level sensors to provide a new fluid level sensing device that is versatile, inexpensive, can be provided in mass quantities, is reliable, will work with sloshing fluids, can be used in harsh environments, utilizes well-known technology that is being applied to a new purpose, and may be capable of providing more information about a fluid or fluids than just fluid level determination.

[0009] In order to understand how a touchpad can be use as a fluid level and fluid characteristic determining device, it is useful to briefly review operation of a touchpad.

[0010] The CIRQUE™ Corporation touchpad is a mutual capacitance-sensing device and an example is illustrated in FIG. **1**. In this touchpad, a grid of row and column electrodes is used to define the touch-sensitive area of the touchpad. Typically, the touchpad is a rectangular grid of approximately 16 by 12 electrodes, or 8 by 6 electrodes when there are space constraints. Interlaced with these row and column electrodes is a single sense electrode. All position measurements are made through the sense electrode.

[0011] In more detail, FIG. **1** shows a capacitance sensitive touchpad **10** as taught by Cirque® Corporation includes a grid of row (12) and column (14) (or X and Y) electrodes in a touchpad electrode grid. All measurements of touchpad parameters are taken from a single sense electrode **16** also disposed on the touchpad electrode grid, and not from the X or Y electrodes **12**, **14**. No fixed reference point is used for measurements. Touchpad sensor control circuitry **20** generates signals from P,N generators **22**, **24** that are sent directly to the X and Y electrodes **12**, **14** in various patterns. Accordingly, there is a one-to-one correspondence between the number of electrodes on the touchpad electrode grid, and the number of drive pins on the touchpad sensor control circuitry **20**.

[0012] The touchpad **10** does not depend upon an absolute capacitive measurement to determine the location of a finger (or other capacitive object) on the touchpad surface. The touchpad **10** measures an imbalance in electrical charge to the sense line **16**. When no pointing object is on the touchpad **10**, the touchpad sensor control circuitry **20** is in a balanced state, and there is no signal on the sense line **16**. There may or may not be a capacitive charge on the electrodes **12**, **14**. In the methodology of Cirque® Corporation, that is irrelevant. When a pointing device creates imbalance because of capacitive coupling, a change in capacitance occurs on the plurality of electrodes **12**, **14** that comprise the touchpad electrode grid. What is measured is the change in capacitance, and not the absolute capacitance value on the electrodes **12**, **14**. The touchpad **10** determines the change in capacitance by measuring the amount of charge that must be injected onto the sense line **16** to reestablish or regain balance on the sense line.

[0013] The touchpad **10** must make two complete measurement cycles for the X electrodes **12** and for the Y electrodes **14** (four complete measurements) in order to determine the position of a pointing object such as a finger. The steps are as follows for both the X **12** and the Y **14** electrodes:

[0014] First, a group of electrodes (say a select group of the X electrodes **12**) are driven with a first signal from P, N generator **22** and a first measurement using mutual capacitance measurement device **26** is taken to determine the location of the largest signal. However, it is not possible from this one measurement to know whether the finger is on one side or the other of the closest electrode to the largest signal.

[0015] Next, shifting by one electrode to one side of the closest electrode, the group of electrodes is again driven with a signal. In other words, the electrode immediately to the one side of the group is added, while the electrode on the opposite side of the original group is no longer driven.

[0016] Third, the new group of electrodes is driven and a second measurement is taken.

[0017] Finally, using an equation that compares the magnitude of the two signals measured, the location of the finger is determined.

[0018] Accordingly, the touchpad **10** measures a change in capacitance in order to determine the location of a finger. All